

STUDY ON FLOOD SUBMERGENCE AREA MONITORING QUICKLY USING ASAR DATA

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ABSTRACT:

The object of this paper is taking full advantage of ENVISAT ASAR image in differentiating land and water area based on the research of ASAR image character, to work out a efficient method to monitor flood submergence area quickly using ASAR, and to develop a radar processing module focusing on ASAR image. So it can provide a advance practical remote sensing dynamic monitoring method in Flood Control and Hazard Mitigation and disaster evaluation. Base on the remote sensing flood monitoring practice, this paper analyzed the flow of monitoring flood submergence area quickly using ASAR, and developed a special radar processing module in Erdas Imagine software environment. Using this module, and selecting East Dongting Lake as test area, the validity and precision of the module are validated through field investigation and remote sensing monitoring of water area changes in the test area in 2006 and 2007 flood season. Furthermore the water area change of East Dongting Lake in 2006 and 2007 is analyzed.

1 INTRODUCTION

1.1 GENERAL INTRODUCTION

Changjiang River is the largest river of China and its length is 6300 kilometers. Since the origination of Chinese history and culture, Changjiang river basin is an important area for economy, culture, politics and military affairs. According to traditional experience of flood control, how to solve the problem of flood risk in Changjiang river basin becomes a critical factor to promote the prosperity and development of China. Because of the special Terrain feature of Changjiang River, the middle and lower reaches of Changjiang River is the crucial region of flood control. Usually, the elevation of the middle and lower reaches of Changjiang River is lower than flood water level and if the water amount coming from the upper reaches is too large, it is easy to bring big flood disaster. For instance, the flood in 1998, according to the statistical materials of Hunan, Hubei, Jiangxi, Anhui and Jiangsu province, this disaster covers 334 counties, 5271 villages and towns. The collapsed buildings are 2128,500. The flood-affected population is 2316,000. Totally, the economic loss is more than 100 billions Yuan.

Therefore, how to develop real-time flood monitoring and loss evaluation system is very necessary. Quick acquiring of submerged area is the basic of flood monitoring and loss evaluation system. Recently, with the fast development of remote sensing, it becomes an important technique in disaster monitoring and evaluation. Microwave remote sensing has special advantage and potential in flood monitoring because it has characteristics of full-time, all-weather. According to domestic and foreign experiences, microwave radar remote sensing can be selected as useful tool to monitor flood disaster.

1.2 ASAR image introduction

An Advanced Synthetic Aperture Radar (ASAR), operating at C-band, ASAR ensures continuity with the image mode (SAR) and the wave mode of the ERS-1/2 AMI. It features enhanced capability in terms of coverage, range of incidence angles, polarization, and modes of operation. This enhanced capability is provided by significant differences in the instrument design: a full active array antenna equipped with distributed transmit/receive modules which provides distinct transmit and receive beams, a digital waveform generation for pulse "chirp" generation, a block adaptive quantisation scheme, and a ScanSAR mode of operation by beam scanning in elevation.

Data from the ASAR instrument supports many industries such as fishing, shipping, agriculture, oil and gas exploration and the military. Especially in cloudy and rainy environment, ASAR has wide application prospect when spectral remote sensing can not be effective.

ASAR is an active microwave remote sensing, comparing with spectral remote sensing, such as TM, SPOT, IKONOS, it has advantages and characteristics in the fast monitoring of submerged area and the main advantages are listed as following:

- ASAR is an active microwave remote sensing, it sends microwave from sensor, because of mirror reflection characteristics of water surface, the scattering of water surface is weak and it seems to be black in ASAR image. However the scattering of land and building is strong and to be white or gray in ASAR image. Therefore, there is apparent discrimination between water and other materials and it is easy to separate water region from land region selecting appropriate segmentation threshold.
- ASAR has characteristic of full-time, all-weather. SAR (synthetic aperture radar) is an active sensor, which is works on microwave band, it can survey the earth surface

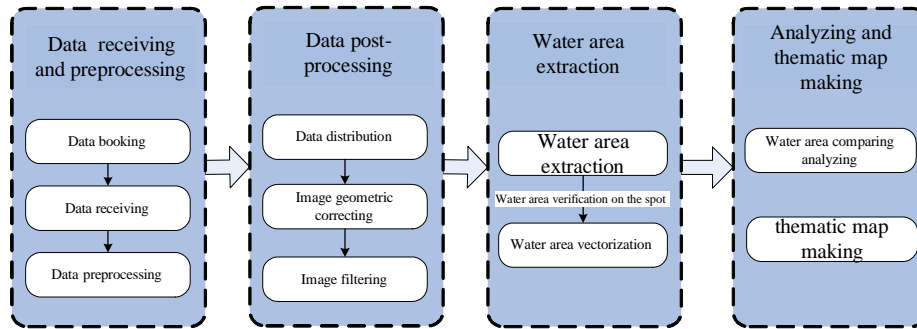


Figure 1. Flowchart of quickly flood submergence area monitoring

without the influence of sunlight and weather conditions and it has the ability of penetration. These characteristics of ASAR are very important in flood season, because spectral remote sensing can not acquire useful image at this time.

- ASAR image has high spatial and temporal resolution. Wave and Alternating Polarisation modes: 30m x 30m. Wide Swath mode: 150m x 150m. Swath Width Image and alternating polarization modes: up to 100km, Wave mode: 5km, Wide swath and global monitoring modes: 400km or more. By adjusting incident angle, the sustained obtain of image of special region is feasible.

2 FAST FLOOD MONITORING PROCESSING

ASAR images are selected as the basic satellite remote sensing data and the process mainly includes following steps: ① receiving and pre-processing of satellite images. ② data post-processing. ③ water area extraction. ④ analysis and thematic map making. And the detailed process is shown in Figure 1.

① ASAR image booking

The ASAR image booking includes two steps: step one, according to research requirement, geographical position and range of image should be confirmed. Step two, real-time query of ASAR sensor track can be obtained using software Descw, which is supplied by ESA(European Space Agency). Then, Satellite ground workstation can submit data receiving application to ESA and data booking will be finished after the confirmation of ESA.

Receiving of ASAR image

② Following the ASAR image booking, satellite ground workstation is responsible for the data receiving at corresponding time and this task can be automatically finished according to the order of administrator. The data is saved as Level10 and it's the original data.

Pre-processing of ASAR image

③ Original ASAR image should be processed in ASAR ground workstation using special hardware and software. And original data change from level10 to level 1b and browse data. These data includes elementary geographical coordinate, and the format is *.N1. It can be opened in professional remote sensing software, such as ERDAS and EVNI.

④ Distribution of ASAR image

The distribution of ASAR image is transmission of pro-pressing image from satellite ground receiving terminal to

user. And this work can be done on internet.

⑤ Geometrical correction of ASAR image

Grid data of Control point included in Geo-location Data set which exists in ASAR data can be used to build transform model. Geographical coordinate can be produced and coarse geometrical correction is accomplished.

The image after coarse geometrical correction has long. /lat. Coordination, but without projection. So it necessary to add projection to GeoTiff image with geographical coordinate. UTM/WGS84 projection can be used and image can be resampled as .img file.

Geometrical position accuracy of ASAR with addition of geographical reference coordinate can not be ensured and more geometrical correction should be implemented. Then different time, modes images can be overlaid together. This task can be finished in Erdas. Choosing one image as reference, geometrical deformable model can be calculated by a matching method of homonymy points on other image.

⑥ Filtering of ASAR image

Speckle noise usually brings trouble in interpretation and application of SAR image, how to decrease the influence of speckle noise is a key step of SAR image processing. So it is necessary to take effective methods to filter SAR image. In this system, Gamma-MAP filter is taken as effective algorithm to reduce speckle noise.

⑦ Extraction of water area

After speckle filtering, ASAR image can be taken as input data to water area extraction. Water area can be extracted by analyzing the gray histogram of ASAR image. And the threshold between water body and land can be recognized automatically according to a special threshold selection algorithm.

⑧ Water range verification on the spot

To verify the effectiveness of water range extracted by satellite image, verification on the spot is necessary and important. The test method is that we can go to the research area to do ground test by the help of GPS when the satellite image is receiving.

⑨ Vectorization of water area

After binaryzation of ASAR image, water surface is separated from land, but it is still raster data. It is common that vector data can be used conveniently in some application and analysis. After vectorization by tool "raster to vector", which is included in Erdas. After vectorization, there are lots of "Small Island"

and a filter algorithm based on area calculation can be used to eliminate “Small Island”.

⑩Comparative analysis of water range and special map
 After extraction of water surface, we can analyze submerged range of research area according to series of extraction results obtained at different time. At the same time, flood submerging special map can be made too.

3 SPECIAL SOFTWARE DEVELOPMENT AND TEST

The special software plate of ASAR data processing is developed based on professional remote sensing software (ERDAS IMAGINE). The developing language is EML and Visual C++. The final special software is WaterInfo. It includes the function of ASAR image input, addition of geographical coordinate, geometrical correction, speckle noise removal, water body extraction, vectorization and so on.



Figure 2. Interface of Waterinfo Model

To test the effectiveness of ASAR data processing method and software plate, two kinds of ways is used. The first one is consistent analysis which is overlaying the vector border of water surface on remote sensing image. If the consistent is good , the effectiveness of software plate is proved. Figure 3 is the overlay result of water body border and remote sensing image. The second method is ground truth test. Using ASAR IMP data in Dongting lake, September 1, 2006. We take ground investigation at that day. During two days’ time, 29 different kinds of samples are picked equally and include 6 water body samples, 23 land samples. Using WaterInfo software plate, the compare between water range from ASAE image and samples prove the high consistent of software extraction and image visual judgment. Test experiment confirms the effectiveness of software plate WaterInfo.

4 MONITORING RESULTS AND ANALYZING OF THE TEST AREA

4.1 General situation of the test area

In the paper, in order to check the reliability of the research results and the practicability of the flood monitoring model, the East Dongting Lake is selected as the test area because it’s flood control position is very serious. To comparing and analyzing obviously, the boundary of the test area is along the dike of the Dongting Lake. The location is shown in Figure 4.

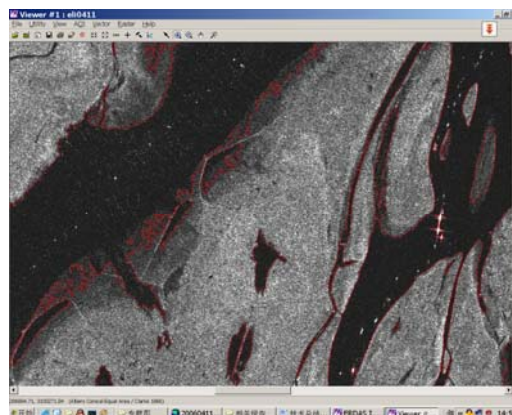


Figure 3. The image overlaid with water area boundary

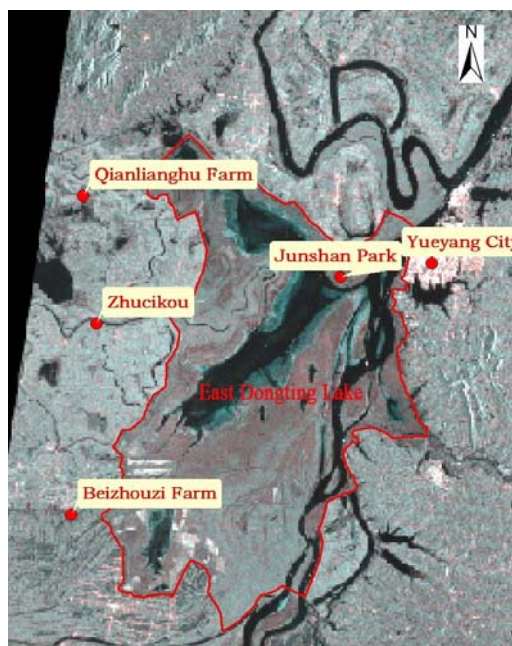


Figure 4. The location of East Dongting Lake

4.2 monitoring results analyzing of the test area

In this paper, 17 scenes of ASAR images were collected from April 2006 to July 2007. The information of the images are listed in table 1. From the series images we can see that in April the East Dongting Lake is in low water seasons and the area of lake beach is much big. While in June and July the East Dongting Lake is getting into high water seasons and the water area is expanded, and the Junshan Park has being an island.

Since August, the water area becomes smaller and smaller. Particularly in October only a small area of the lake center and the Xiangjiang riverway is covered with water and large area of

beach is above of water surface. The area around Junshan Park became largescale land.

No.	Date of image	Model of image	polarization mode	Incident band	orbit
1	Apr.11 2006	APP	HH/VV	IS6	Descending
2	Jun.15 2006	APP	HH/VV	IS1	Descending
3	Jun.23 2006	IMP	H/H	IS4	Descending
4	Jun.28 2006	IMP	H/H	IS2	Ascending
5	Jul.28 2006	IMP	H/H	IS4	Descending
6	Aug.13 2006	IMP	H/H	IS5	Descending
7	Aug.16 2006	IMP	H/H	IS3	Descending
8	Aug.21 2006	IMP	H/H	IS3	Ascending
9	Sep.1 2006	IMP	H/H	IS4	Descending
10	Sep.17 2006	IMP	H/H	IS5	Descending
11	Oct.6 2006	IMP	H/H	IS4	Descending
12	Mar.11 2007	IMP	H/H	IS4	Ascending
13	Apr.15 2007	IMP	H/H	IS5	Descending
14	May.20 2007	IMP	H/H	IS4	Descending
15	Jun.24 2007	IMP	H/H	IS4	Ascending
16	Jul.13 2007	IMP	H/H	IS5	Descending
17	Jul.29 2007	IMP	H/H	IS4	Descending

Table 1. The received ASAR image in 2006 and 2007

After the processing by waterinfo model, the series images became corresponding water area vectorgraphs. Then the vectorgraphs are smoothed and converted to thematic map in Arc/INFO format. After statistics, the water area of the test area is listed in table 2.

July the water area is biggest in one year. But from August the water area decreases continuously, and at Oct. 6 2006 the water area is smallest which is only one sixth of that in June. In 2007 because there was more rainfall in Changjiang River basin, the water level of Dongting Lake is higher than which in 2006. The water area at Jul.29 2007 is bigger than the biggest water area in 2006.

Date of ASAR image	Water area (m ²)
Apr.11 2006	266042162
Jun.15 2006	721702810
Jun.23 2006	845541082
Jun.28 2006	797611433
Jul.28 2006	820426535
Aug.13 2006	498242677
Aug.16 2006	394788418
Aug.21 2006	356822580
Sep.1 2006	260579400
Sep.17 2006	325967518
Oct.6 2006	164504506
Mar.11 2007	306219967
Apr.15 2007	205197528
May.20 2007	263351495
Jun.24 2007	902286853
Jul.13 2007	854599704
Jul.29 2007	1057537505

Table 2. The water area of the test area in 2006 and 2007

Based on the data in table 2, the change curve of the water area is gained and shown in Figure 5. The Figure 6 shows the water area change of East Dongting Lake from April to October in 2006..

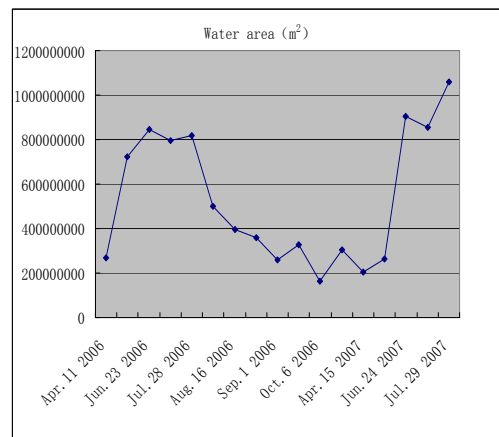


Figure 5. Water area change curve in East Dongting Lake

5 CONCLUSIONS

1) ASAR is the most advanced Synthetic Aperture Microwave Radar on ENVISAT-1 featuring large swath coverage, multiple choice of incidence angles, polarizations, modes of operation. So it has some very particular advantages in monitoring water area change: ASAR is a kind of active microwave remote sensing, so it can differentiate land and water area because the microwave emitted from sensor can form mirror reflection if the incident angle is suitable; Synthetic aperture microwave

From table 2 and Figure 5 we can see directly that from April the test area is getting into flood season slowly, and in June and

radar is an active sensor so it can avoid influence of sunshine and weather condition; it has high special resolution and high time resolution so it can continuous capture the same area's images through adapting the polarization mode and incidence angle.

2) In 2006, the East Dongting Lake slowly came into flood season from April. The water area was largest in June and in July it was at the same level as in June. But since August the water area has been decreased. In October the water area was least and was one fifth of it in June. Because in 2006 the weather of Changjiang River basin was continuous drought, so the water level of Dongting Lake was lower than it at the same time before. While in 2007 because there was more rainfall in Changjiang River basin, the water level was comparably higher. The water area, at Jul.29 2007, was 212 million larger than the largest water area in 2006.

3) Using ASAR image, with modern communication and internet techniques, we can monitor the flood course, obtain the flood submergence area quickly and forecast the flood developing trend. The research results will be credible and important technical support in constituting emergency response plans of people evacuating, emergency service and disaster relief in flood season, disaster evaluation and compensation.

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